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ABSTRACT

The paper reviews neuro-motor development in young children and analyzes the effect of deafness on motor performance. A theoretical overview considers responses of the newborn infant and discusses findings from studies on motor development in early childhood. Such environmental influences as interpersonal family relationships, socioeconomics, and parent attitudes toward the child's development are analyzed, as are motor-cognitive relationships with young normal and deaf children. (CL)

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MOTOR DEVELOPMENT IN DEAF AND NORMAL-HEARING CHILDREN: A REVIEW OF THE LITERATURE

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INTRODUCTION

This paper has been developed in order to better understand motor development and to tie together various theories and research data relative to the acquisition and development of motor skills. Major attention is focused on the child age 0-6 and motor skills as they are acquired during that developmental period. Motor-environmental and motor-cognitive relationships are investigated with a presumption that these areas of development, along with others, somehow interrelate and influence the development of the whole child.

A segment of this paper also deals with motor development as it occurs in deaf children. The effect of deafness on motor performance is investigated with special emphasis on specific causes of hearing impairment which affect motor performance in different ways and to various degrees.

This paper will not deal to any extent with the area commonly referred to as sensory-motor development. Rather, this investigation will be limited to what might best be termed normal neuro-motor development in young children.

THEORETICAL OVERVIEW

The sequence of physical development has been found to be orderly and predictable; as physical growth takes place, the motor

sequence seems to follow a similar pattern. Approaches to the study of motor development during infancy and early childhood generally take two forms. The first is concerned with general motor development during the first few years of life. This approach more or less deals with the motor 'unfolding" of the child as a part of the overall behavioral development during infancy and early childhood (Bayley 1935 and 1969; Gesell and Amatruda 1947; Frankenburg and Dodds 1967; Knobloch, et.al. 1966). The second approach to motor development concerns the development of specific postural states and movement patterns (Hellebrandt, et.al. 1961; Wild 1937). Motor development in the child age 0-6 can be divided into three periods: neonatal, babyhood and early childhood (Corbin 1973). During the prenatal period, the central nervous system is being formed and developed. This system is, of course, important to motor behavior.

When the infant is born, he already has a number of motor responses available to him. The following table summarizes these responses:

Responses of the Newborn Infant

Eyelid responses. Opens and closes eyelids; this appears spontaneously and in response to a variety of external stimuli.

Pupillary response. Pupils contract and expand in response to light. The pupils tend to be consensual (when one is stimulated, the other eye also responds.)

Ocular response. There are pursuit movement, and saccadic movements which are quick, jerky movements used later in reading.

There is coordination of the eyes, with convergence being rare. Eyes in sleep are up and sideways like the adult.

Tear secretion. Tear secretion is unusual in the newborn but has been observed during crying and with nasal irritation.

Facial and mouth response. Opens and closes mouth; lips move in response to touch; sucking occurs either spontaneously or in response to tactual or taste stimuli; smiles; yawns; frowns; wrinkles forehead; grimaces.

Throat response. Crying is usually accompanied by activity of arms and legs. Swallowing occurs in all newborn infants, vomiting may occur, hiccoughing may occur, sneezing may occur and holding breath has been reported.

Head and neck response. Moves head upward and downward and turns face to side in response to some stimuli. As early as two days of age the baby can balance his head in response to changes in bodily positions.

Head and arm response. Closes hand in response to tactual stimulation of fingers and palm. Arm flexion can be elicited with pricking the hand or a tap on the hand. Rubs his face, and moves his arms. The startle response is evident - throws arm outward if startled.

Trunk reactions. Arches back-can be produced by pinching the nose.

Twisting-head rotates one direction, shoulders and pelvis in the opposite direction.

Abdominal reflex-draws in stomach in response to needle stimulus.

Sexual responses. Cremasteric reflex-raising of testes to stimulation of inner thighs.

Penis erection.

Foot and leg responses. Achilles tendon reflex is present in most newborn babies.

Flexion of leg-this action is accompanied by plantor flexion of the foot.

Kicking consists of a pedaling action and a simultaneous flexion and extension of both legs.

Stepping movements occur when the child is held upright with its feet touching a surface.

Toe phenomena consists of spreading the toes when the sole of the foot is stroked.

Coordinate responses of many body parts. Resting and sleeping position-the legs are flexed, fists closed, upper arm straight out from the shoulders with forearms flexed at right angles so they are lying parallel with the head.

Opisthotonis position-this is a strong dorsal flexion from head to heels, often occurs in crying.

Backbone reflex-this is a concave bending of a side that is stimulated with a stroke or a tickle.

Lifting head and rear quarters simultaneously.

Fencing position-this occurs when the baby's head is rotated to one side, the arm toward which the head is rotated will extend and the opposite arm will flex.

Springing position-this occurs when the infant is held upright and inclined forward. The arms extend forward and the legs brought up.

Startle response-this response consists of throwing the arms apart, spreading the fingers, extending the legs and throwing the head back. It sometimes occurs with no apparent stimulation but is usually a response to stimuli which could frighten it such as noise, falling or other sudden occurences.

Mass activity-general unrest and crying.

Creeping-this may occur when newborn is placed in a prone position. The legs and arms are drawn under the body and the head lifted. The legs push and the arms become more active.

Nursing posture-if an infant is hungry and given a nipple, it begins to nurse and at the same time it flexes its arms so they are pulled across the body with the fists toward the chin. The legs and toes are raised. The position relaxes as the child's hunger subsides.

Abridged from Wayne Dennis. "A Description and Classification of the Responses of the Newborn Infant." Psychological Bulletin 31 (1934): 5-22, Copyright 1934 by the American Psychological Association.

It is believed that the cerebral cortex does not influence behavior until a few months after birth. In a short time, however, the infant is capable of making some voluntary movements although most activity during this early period is reflexive. Three of the more common reflexes observable in the neonate are: the Moro reflex, the grasping reflex and the Babinski reflex. The Moro reflex involves throwing the arms outward from the body, followed by bringing them together. This is a response to stimuli that may startle the infant. This reflex appears at about age 4 months, although a startle reflex of a different nature continues to exist in adults. The grasping reflex occurs when the palm of the infant is pressed and causes a closing of the fingers. This grasp can be strong enough to allow the neonate to support his own weight. This reflex also disappears after a few months. The Babinski reflex is an extension of the big toe and extension and spreading of other toes when the sole of the foot is stroked. Several months after birth, this reflex too disappears (Hottinger in Corbin 1973).

Soon after a baby is born, he can tell light from darkness and can distinguish between different patterns. In addition, the infant has auditory awareness, although at times he appears to be oblivious to environmental sounds (Goldstein 1933).

Babyhood covers the period from approximately one month to two years. This is considered the first critical period of learning

during the baby's development. A critical period is a point at which the child can most effectively perform an act (Hottinger in Corbin 1973). In studies with animals, it has been clearly shown that the development of behavioral responses is dependent not only on maturation but also on the opportunity for the animal to respond actively to environmental stimuli. If such opportunities are not afforded at the period when these behaviors would usually be expressed, they are not likely to develop normally (Singer in Rarick 1973). Furthermore, that which is learned in one period of development may be crucial in later learning.

Longitudinal studies of the development of fine and gross motor skills indicate that individual differences in these abilities are evident in infancy and remain remarkably constant through this period and into the childhood years. Gesell (1937) using cinematographic observations of children engaged in routine motor tasks in the home, found that the rank order of the motor behavior of the 5 children under investigation was the same at 5 years of age as it had been in early infancy. Ames (1940) reported constancy of individual differences in locomotor and manipulative behavior of 8 infants observed over a period of 3 years. These studies seem to indicate that infant individual differences in motor behavior persist through early childhood. Edwards (1968) in a follow-up study related to the works of Chess (1959) and Birns (1965) found that the correlations

between the 1 minute Apgar score at the neonatal level and measures of fine and gross motor coordination at 4 years of age were .446 and .493, respectively, and that the muscle tone at birth accounted for more of the variance in the latter scores than any of the other four Apgar rating scores (heart rate, respiratory effort, reflex irritability and color) (Rarick 1973).

In Germany, Professor Liselott Diem (1970) is investigating means of introducing swimming techniques to babies as young as two months of age. Long-term effects will be noted, and the data collected will provide the basis for comparative analysis. Her initial efforts have resulted in babies being able to swim without assistance at about 5 months of age.

The work of Gesell, Ames and Edwards suggests that motor behavior is genetically based and tends to unfold automatically and maintain its individuality. While Diem's work does not argue against such a theory, it does provide evidence that early intervention can enhance motor skill acquisition. In addition, Diem's work might eventually lead us to conclude that "critical periods" occur much earlier than we are now able to say with certainty.

Returning to development during the babyhood period, it can be said that this period provides a basis for some of the most significant accomplishments that will take place in the child's

lifetime. The period from 6 weeks to 3½ months is marked by the following significant motor developments:

1. discovery and at least partial mastery over the use of the hands,
2. the capacity to maintain clear focus on objects moving nearby,
3. a tendency to blink at approaching objects,
4. a gradual disappearing of the grasping reflex,
5. control of the tonic neck reflex which allows for a wider visual range,
6. the capacity to hold his neck vertically for several minutes when placed prone, and
7. the ability to imitate sounds. (White 1971)

One of the most important developments after 3½ months is the child's ability to reach. Reaching, grasping and manual manipulation are referred to as prehensile behaviors. Initially, the infant's strong grasp is a reflex action. This reflex grasp gradually disappears and is replaced by prehensile grasping which gradually comes under voluntary control. Halverson (1931) was able to identify 10 stages in the development of prehension. The stages occur in sequence as follows:

1. no contact----------16 weeks
2. contact----------20 weeks
3. the primitive squeeze-------20 weeks
4. the squeeze grasp----------24 weeks
5. hand grasp----------28 weeks
6. palm grasp----------28 weeks

7. superior palm grasp--------32 weeks
8. inferior forefinger grasp--36 weeks
9. forefinger grasp-----------50 weeks
10. superior forefinger grasp--52 weeks

If the baby is provided with objects that he can manipulate and control, his prehension abilities can be enhanced.

Another important motor function of the maturing infant is the attainment of the upright position which leads to walking, running and other skills. Sitting is considered an early developmental milestone and is behavior that occurs rather automatically. This type of behavior change is referred to as phylogenetic. There is evidence which shows that the pattern does follow an orderly sequence. The changes which occur appear to follow, or are closely associated with, maturity of the central nervous system (Shirley 1933). The infant must initially gain control of the muscles of the head and neck. By six months, the infant has considerable control of his neck and trunk. At about the same time, the child has tried, or soon will try, to make some forward progress. Dennis (1963) in studying institutionalized children aged 1-4 in Iran found that children who were not provided with specific kinds of learning opportunities were retarded in normal locomotor development including sitting.

While this development is taking place, the lower trunk has been growing stronger allowing the child to be able to sit alone

with support at 4 months and alone by 7 months. Around 7-9 months he begins creeping, an act which greatly expands his environment. This is a period of exploration of objects and space using the eyes, ears, fingers and mouth. There are many kinds of sensory experiences that the baby is able to assimilate at this time (Hottinger in Corbin 1973). There is ample research to show that the child's freedom to explore expands his capacity as he responds to the varied stimuli. It is through exploration and movement that perception is developed. He is exposed to concepts of size, shape, weight, distance and color; concepts which serve as a foundation for symbolic learning (Flavell 1963).

Between 7-10 months, a baby's trunk and legs have developed to the degree that allows him to stand with support and he begins to pull himself erect by holding on to furniture. Soon he begins to walk around the furniture using it or his parents as aids. While the average age for walking seems to be between 13-14 months, the developmental range is between 7-18 months. Parents often get quite involved in the process leading up to walking and the act itself and take self-satisfaction when this motor act is finally acquired. Some parents will mistakenly force walking before the child is ready, thinking that the acquisition of this motor act and intelligence are somehow related. Most studies, however, argue against any correlation between walking and intelligence

(Rabin 1958; Goetzinger 1961; Singer and Brunk 1967) and in 1900, Bayley even found an inverse correlation between mental and locomotor ability. Actually a child will walk when he is ready; that is when his muscular and nervous systems mature to the degree which allows him to engage in this new motor act. In a longitudinal study of walking behavior, it was found that walking was perfected at about 50 months (Hottinger in Corbin 1973).

Prehension and upright position serve as the basis for the development of many and varied motor skills; walking being just one. The following scale classifies various motor achievements in sequence and the average age of acquisition:

Development of Motor Abilities

.2 months	crawling movements
.5 months	lifts head at shculders
1.7 months	arm thrusts in play
1.9 months	head erect-vertical
2.6 months	dorsal suspension-lifts head
2.9 months	head erect and steady
3.4 months	turns from side to back
3.5 months	sits with support
4.1 months	beginning thumb opposition
5.0 months	turns from back to side
5.4 months	effort to sit
5.7 months	sits alone momentarily
6.2 months	pulls to sitting position
6.2 months	sits alone 30 seconds or more
7.0 months	rolls from back to stomach
7.6 months	complete thumb opposition
8.5 months	sits alone with good coordination
9.2 months	prewalking progression
9.3 months	fine prehension with pellet
9.4 months	raises self to sitting position
10.5 months	pulls to standing position
10.6 months	stands up
11.6 months	walks with help
12.5 months	stands alone
13.0 months	walks alone
16.5 months	walks sideways
16.9 months	walks backwards
20.3 months	walks upstairs with help
24.3 months	walks upstairs alone-marks time
24.5 months	walks downstairs alone-marks time

Abridged from Nancy Bayley, "The Development of Motor Abilities During the First Three Years." Society for Research in Child Development, Monograph No. 1 (1935): 1-26

It should be pointed out that Bayley's observations were recorded in 1935. Gesell in 1954, however, made similar observations and Bayley's work is still considered the most representative of motor development.

Perhaps the most important achievement of a child in the first two years of life is to gain sensory control over his environment. In Dennis' study (1963) cited earlier, the majority of children in one of the institutions, where sensory stimulation was minimal, did not learn to creep prior to walking, but rather scooted. Scott (1968) found a significant correlation between enriched environments and early motor skill acquisition. Brazelton (1971), while pointing out the need for a stimulating environment, had two concerns: (1) that the stimulation be appropriate for each baby (stimulation beyond the maturational level of the child will not produce positive results) and (2) that there is not over-stimulation. In summary, the following conclusions seem to emerge relative to sensory stimulation during the babyhood period:

1. sensory stimulation is important to the development of the whole child,

2. the kind and degree of sensory stimulation is important,

3. the kind of sensory stimulation the child needs will depend upon his particular developmental level, and

4. as the child develops, the nature of the sensory stimulation will change and requires that the

environment become more varied.

Early childhood is regarded as the period from 2-6 years and is a significant learning period. Most of the fundamental movement patterns develop to a fairly high level provided the environment furnishes ample opportunity. As with the period of babyhood, stimulating environmental conditions are important to early childhood motor development.

One systematic study of the effects of an impoverished environment was carried out by Dennis and Dennis (1936). They studied the development of two children whose first year of life contained an absolute minimum of social contact and minimal opportunity to practice any activity. The experimenters entered the room only for the physical care of the children; the children never left the room. The room had no toys or decorations and was generally sensorially unstimulating. The infants were not rewarded or punished for anything. They did not interact at all and did not see each other except when they were lifted from their crib for care. Physical health was, however, carefully maintained. Raised under these conditions, the children were severely delayed in three types of motor activities: visually directed reaching, sitting alone and standing with support. The experimenters did say, however, that the children promptly learned these activities upon the initiation of a training program. In other words, no permanent stunting of development was observable.

In studies of feral children - children who live without human companionship - it is found that these individuals do not develop language and tend to take on the characteristics of the animals with whom they associate (Gesell 1941). While these studies are of an extreme nature, they serve to point out the importance of the environment as an influence on the motor development of the child during early childhood.

Walking, as discussed earlier, is one of the first beneficiaries of creeping and standing behavior. Walking then joins with creeping and standing to provide an enlarged base for other movement patterns such as climbing, running, jumping, hopping, galloping and skipping (Corbin 1973).

In a study of climbing ability in children, it was found that by the age of 24 months children could ascend a ladder with rungs 12 inches apart. They could skip rungs by 41 months of age. Ascending proved easier than descending; the latter skill following in 4-5 months. By 62 months the child could descend the ladder (Wellman 1973). Gutteridge (1939) found that 92% of the children in his study were proficient climbers by age 6. In general, there is little difference between preschool boys and girls in their ability to climb; descending is more difficult than ascending; higher heights may cause children to revert to an earlier climbing pattern, and there is wide variation in ability at all ages.

Shortly after the child has some skill in walking and running, he begins to jump. Greater strength is required for jumping than running since the body must be propelled upward. At around 24--30 months, jumping occurs from elevated levels and this precedes jumping with both feet simultaneously and jumping over barriers. Gutteridge (1939) judged that 42% of children at 3 years of age were able to jump well, and by age 5, 81% were reasonably proficient.

Hopping is more difficult than jumping because it requires a one foot take-off and landing on the same foot. Breckenridge and Vincent (1956) state that children are 6 years old before the majority can hop skillfully. There is a wide range of ability as children have been observed to hop 100 feet or more without stopping by 5 years of age. Girls generally become more proficient hoppers at an earlier age than boys, although there is a wide variation in the ability to perform this skill with both sexes.

Galloping and skipping combine walking and leaping with galloping preceding skipping. At 5 years of age, children gallop fairly well and at about 6½ years are quite skillful.

Another skill which begins in early childhood is throwing. The earliest crude throwing pattern occurs when a child releases an object from a jerky movement. Throwing is a learned or ontogenetic behavior. Cultural opportunities and expectations play a major role in its development. Girls generally do not learn to

throw well and most of them never achieve a high level of skill. Many men who live in countries where ball throwing is not emphasized often lack mature throwing form. Catching, as with throwing, is a behavior in which a wide range of skill in terms of age of acquisition and proficiency can be expected. By the time a child is 2 years old, he can handle stationary objects, but grasping a moving object presents a more complicated challenge (Corbin 1973).

Swimming is another skill which can, as noted earlier, be learned at an early age. Children can become reasonably proficient by the age of 5 if given the opportunity. As mentioned earlier, Professor Diem (1970) has started to introduce swimming to 2 month old infants. Some babies have begun swimming at 5 months (Singer in Rarick 1973). McGraw (1935), in her twin study, found Johnny was able to swim 12 to 15 feet by 17 months. Mead (1958) in describing the Manus tribe of New Guinea, states that children are expected to swim by 3 and that all children can swim well by age 5.

The number of activities that can be learned by the child from birth to age 6 is almost unlimited. It is important, however, to remember that a wide variation of motor skill acquisition and performance is evident during this 6 year period. This variation can be explained by a number of factors such as: hereditary endowment, opportunity to experiment and practice, attitude of parents toward motor performance, peer interaction and environmental conditions.

MOTOR-ENVIRONMENTAL RELATIONSHIPS

Because of the importance and ever present influence of the environment on motor behavior, studies related to this relationship are sprinkled throughout this paper. However, this section will focus solely on the environmental issue. Environmental factors which may influence motor development include, for purposes of this section, the following: the family unit and the interpersonal relationships therein, the socioeconomics of the family, the attitude of the parents toward all aspects of the child's development and the experiences, both physical and sensory, to which the young child is exposed. While researchers have considered these environmental factors, they have usually related them to cognitive or personality development (Flavell 1963; Furth 1966; Bruner 1966).

Experimental work on a variety of organisms has clearly shown that the development of behavioral responses is dependent not only on maturation, but also on the environmental stimuli and the opportunity for the animal to respond to these stimuli (Singer in Rarick 1973). Data revealed that Scottish terriors raised in competitive situations were more aggressive at maturity than those of the control group. The restricted dogs were inept in competitive situatios, curiousity and social behavior. Ravizza and Herschberger (1966) have shown that rats raised in an inhibited

environment where no climbing was permitted differed in adulthood from rats allowed to climb. The restricted group was less active in exploration tasks, more emotional in novel situations and inferior on an intelligence test.

There is available data which indicates that mothers treat their sons differently than they treat their daughters, and that this sex difference begins early in infancy (Moss 1967; Goldberg and Lewis 1969). Boys and girls likewise differ in their behavior early in life. Goldberg and Lewis (1969) discovered in their particular study that 1 year old boys spend more time in gross motor activity while girls of the same age spend more time in fine motor activities. This holds true up to nursery school (Jones 1967; Clark et.al. 1969).

Nancy Bayley (1935, 1965) in her work found no sex differences in motor development. In a study using the Denver Developmental Screening Test, no sex differences were apparent (Frankenburg and Dodds 1967). Significant is that in both instances, the pre-two year old child was observed and tested. Among children ages 2-6, there appear to be significant sex differences. Girls generally excel in tasks of jumping, hopping, rhythmic locomotion and balance, while boys generally perform better in throwing and catching, and in tasks requiring strength and speed (Sinclair 1971; Frankenburg and Dodds 1967). It is significant to know that those

activities in which boys excel are all of gross motor nature.

Bayley and Jones (1937) reported no relationship between socioeconomic variables and age of first walking independently. However, they did note a tendency for an increased number of negative correlations between motor scores and socioeconomic variables; implying a somewhat more rapid motor development in children from the lower socioeconomic groups. This inverse correlation was also found by Neligan and Prudham (1969).

Available data comparing the early motor development of American Negro and White children suggest advanced motor development in Negro children during the first 3 years of life, with the difference being more marked at the younger ages and less apparent at the later ages of early childhood (Malina 1968). Some researchers favor a genetic explanation (Bayley 1965); while others feel there is a significant socioeconomic influence (Scott 1955; Williams and Scott 1953). Scott (1955) felt that a more permissive rearing atmosphere among the lower socioeconomic classes greatly influenced motor development. On the other hand, there are available data reporting that this negative correlation does not hold true for White children; i.e., that in White families motor development among children is not more advanced in the lower socioeconomic group (Knobloch and Pasamanick 1958; Walters 1967).

Furthermore, the evidence indicated that higher class Negro infants were more advanced in gross motor development than lower social class Negro infants. Willerman (1970) made similar observations on White infants; although the oldest of his subjects was only 8 months. It is important to note that a systematic recording of specific activities and physical characteristics of the home are not reported in these studies.

Cultural in addition to socioeconomic factors must also be considered in accounting for the observed sample and population differences. The effects of psychological deprivation during late infancy and early childhood should be considered. For example, after 2 years of age children do not get the adult treatment and attention they had before. Generally by two and three years of age, many African children, initially precocious in motor development, fall below the developmental norms (Geber and Dean 1957).

Another factor which may affect motor development and which can best be considered under the environmental issue is nutrition. It can be assumed that in order to grow and develop normally, a proper diet is necessary. Available data indicates that undernourished infants and young children are retarded in both early mental and motor behavior (Geber and Dean 1956; Monckberg 1968; Cravioto 1968). The persistence of the detrimental changes associated with severe undernutrition are probably dependent upon the

timing, severity and duration of the malnutrition. Children put on nutritionally adequate diets show some catch-up in growth and development. Nevertheless, it is difficult to assess how much of the child's potential is effected by the malnourished condition. In a 3 to 6 year follow-up study of 14 severely undernourished children after nutritional recovery, Monckeberg (1968) noted that motor development was still retarded.

The contrasts between the treatment of the Hopi infant and the treatment of the white American infant is interesting relative to the influence of the environment on motor behavior. Chief among the cultural differences is the binding of the Hopi infant in comparison with the freedom of the American baby. The cradling of the Hopi infant prevents a number of actions which American babies commonly engage in, such as bringing the hands to the mouth, playing with the hands, watching the hands and putting the feet in the air. Nevertheless, observation of a large number of Hopi infants of various ages shows that the characteristic response patterns are the same for the two groups. In spite of the enforced extension of the legs, the Hopi infant, when freed from his bindings for the bath or for the changing of bedding, takes the usual flexed position. Although his hands are held downward, perhaps 23 hours out of 24, when he is free, he puts them to his mouth and carries objects to his mouth as do white babies. He reaches for objects and handles

them at approximately the same time as do white children. He reaches for his toes and puts his toes in his mouth. Sitting, creeping and walking follow in the usual sequence (Dennis in Barker, et.al. 1943).

Differences among studies confuse the socioeconomic/environmental-motor development issue. Permissiveness as a factor needs to be well-defined and other influences such as physical activities, sensory stimulation and interpersonal family relationships need to be evaluated.

MOTOR-COGNITIVE RELATIONSHIPS

Theories of cognitive development have provided insights into the relationship of motor development and intelligence (Bruner 1966; Flavell 1963). These theories fittingly describe the first period of the developmental continuum as the sensori-motor period, a period during which the infant depends primarily upon direct sensory stimulation t igger specific motor behavior. This phase usually covers a period from birth to approximately the age of 2 years. During this period, the infant creates a practical world entirely linked to his desires of physical satisfaction within his immediate sensory experience (Flavell 1963). The major developmental tasks of this period are the infant's coordination of his actions or motor activities and his perception or sensori-perception

into a tenuous "whole". In other words, the new organism must find himself an active part of his environment and must be able to perceive his environment within the horizon of his immediate experience (Maier 1965).

Therefore, sensory control over his environment becomes one of the most important challenges facing the child. This control will be influenced by the environment and, once accomplished, will greatly influence and advance cognitive development. There can be no doubt that motor behavior provides the basis for symbolic learning (Flavell 1963). In fact, the first responses of an infant are motor responses and his progress through early life is measured in terms of his movements; even his intelligence is determined by his motor responses (Vineland). Movement in the early years is considered an essential ingredient in concept development (Flavell 1963), perception of objects (Orem 1965), visual symbolic learning (Getman 1964) and creativity (Frostig 1970). Some well-known and respected educators have used a motor program to teach academic subjects with success (Frostig 1970; Humphrey 1965; Cratty 1969).

There is evidence linking the thought and mediation process to control over motor movements (Singer in Rarick 1973). Verbal direction was given to a child squeezing a rubber balloon. The child shows increasing control over his actual movements in a

period from 18 months to 5 years. At about age 5, the child can effectively transfer behavioral control from overt verbalization to self-verbalization (thought) over task execution.

In school aged children and adolescents, performance in motor skills has been found to have a low relationship with intelligence test scores (Singer 1968; Chang and Chang 1967; Bruininks 1969; Lawton and Seim 1973). The relationship between cognitive and motor abilities in preschool children shows a more meaningful relationship (Bayley 1935). Bayley administered the California Infant Scale of Motor Development to 61 infants each month from birth to 15 months, and at 3-month intervals from 15 to 36 months. A correlation of .50 was obtained between the motor and cognitive items given during the first 15-month period. A correlation of .39 was found between the age of walking and age of talking.

In a study where children under the age of 5 were asked to pair like-toys, it was found that those children who interacted with the toys were able to re-pair significantly more toys than those children who were instructed to form associations "in their head" and were not allowed interaction with the toys (Wolff, Levin and Longobordi 1972).

In such a paired-associate recognition task, the child presumably must recreate the image he formed originally in order to re-pair the toys correctly. This process has been hypothesized

to require internalized motor activity which is some function of the overt activity involved in the formation of the original image (Piaget and Inhelder 1971). Longobordi, Wolff and Levin (1974) replicated their 1972 study with one major modification: 5 and 6 year old children were paired, and the observer watched his mate pair the toys. In this study, they found no significant differences between observers and performers. They did, however, rank performances as follows:

1) retention is best when the child can both actively manipulate the toys and observe the effects of his activity,

2) performance is significantly better when the child is allowed either active manipulation of the toys with no visual feedback from his activity or visual access to the interacting pairs, and

3) the worst performance is found when the child is not permitted to engage in or observe overt activity involving the toys.

Chang and Chang (1967) found a significant correlation between reading, I.Q. and visual-motor development in children 6 and 7 years old. By age 8 and 9, this correlation diminished to an insignificant level. Singer and Brunk (1967) did a similar study with children ages 8 and 9 and found that there was no apparent relation between motor test scores and intellectual test scores; although the Pearson r between motor performance and I.Q. was highest with the youngest children. Lewis, Bell and Anderson (1970), however, found a signi-

ficant positive relationship between the reading scores and motor performance scores of 100 junior high school males. The bulk of the evidence, nonetheless, favors an interrelationship of motor ability and intelligence among preschoolers (Kephart 1960, 1964; Delcato 1966); with greater specificity as the children get older (Henry and Nelson 1956; McCloy 1934; Rabin 1958; Goetzinger 1961). It seems an important fact that some researchers have found significant correlations between motor development and intellectual ability with children ages 5 and 6. To better investigate this apparent phenomenon, research is needed on the child age 0 to 5; and systematic observations must be made and recorded on the same children over a long period of time. The focus of such a longitudinal study should be on the types of activities in which the child engages. In addition, intelligence must be defined. Numerous psychologists suggest that there are different kinds of intelligence. Thorndike said intelligence might be divided into three types:

1) abstract intelligence or the ability to deal with the symbolic, e.g., a word, a code or a geometric figure,

2) mechanical intelligence or the ability to deal with concrete objects, and

3) social intelligence or the use of psychological principles involving problems of human relationships (Dinkmeyer 1965).

THE MOTOR DEVELOPMENT OF DEAF CHILDREN

Experimental psychology has indicated a relationship between the sensory channel and reaction time. In general, the quickest reaction time has been associated with auditory sensation (Bills 1948). Such a finding has relevance to the study of motor capacities in hearing impaired children. However, there are other relationships between deafness and motor functioning which must also be investigated. For example, it is known that impairment of the semicircular canals results in reduced ability to maintain motor balance and equilibrium. Deaf children also appear to be inferior to hearing children in discrimination of visual temporal patterns (Sterritt 1966; Mykelbust and Brutten 1953). Both motor retardation and motor disturbance, such as apraxia and ataxia, can be expected to occur in addition to deafness in certain children (Mykelbust 1960). Thus, the study of motor performance in hearing impaired children entails all these possibilities in addition to the direct effect of deafness.

Two of the most common ways of studying motor capabilities are the strength or force of the motor act, and the speed with which it is performed (Bills 1948; DeJong 1950). A number of investigators have indicated that speed concepts are difficult for deaf children. Hiskey (1955) suggested that speed tests should not be used in measuring the intelligence of deaf children. Psychologists have referred to the sense of time and temporalness as being mainly

dependent on hearing. There is evidence which indicates that motor speed might be reduced by deafness (Mykelbust 1960). However, as all such functions are complex, it should not be expected that this relationship is a simple one. A third way in which it is common to appraise motor function is through the study of handedness or laterality. A number of studies have shown that children having reading, speech or other types of learning disorders, often have disturbances of laterality (Morley 1957). Associated with these difiiculties is an above average incidence of left-handedness. There is an indication also that these deviations of laterality are more common in those having early life deafness (Mykelbust 1960).

There is considerable evidence from motor and neurological studies that integrity of motor behavior is closely related to integrity of the central nervous system (Mykelbust 1960; Leirne 1960; Goldstein 1933). Therefore, an individual having deafness might have motor disorders chiefly because of inner ear involvement or disturbances of the central nervous system; he might have both of these simultaneously. In such instances, he has organic damage causing both impaired hearing and motor disability.

While specific motor performance data on deaf children is quite limited, there have been some studies completed which point out that deaf children score significantly below hearing children on motor tasks measuring balance (Long 1932; Morsh 1936). Mykelbust (1960),

in an effort to investigate the factor of speed in the manual dexterity of deaf children, found no significant difference in the performance of 80 deaf males, ranging in age from 12-21, and the norms for hearing children. To conclude from this test that deaf and hearing children are equal on motor performance and that speed among deaf children is not diminished would be an overgeneralization.

The Heath Railwalking Test is a widely used measure of locomotor coordination and in diagnosing motor disorders (Heath 1946). Frisina (1955) used this test in his study of mentally retarded, deaf children. He found a significant difference between the deaf, mentally retarded children and the norms of hearing children, with the deaf, mentally retarded children being inferior. Frisina also found significant differences between congenitally deaf, retarded children and adventious deaf, retarded children. When deafness and mental retardation are present because of a hereditary defect instead of from disease or birth trauma, the motor performance is more comparable to normal. When mental retardation and deafness result from brain damage, then motor function is disturbed and is more grossly inferior. In his study, Frisina was not able to account for the effect of the retardation factor on motor performance.

In 1960, Mykelbust studied the motor performance of deaf, hearing and mentally retarded children also using the Heath Rail-walking Test. The children ranged in age from 7-15. At each age level, Mykelbust found significant differences among the three groups. Deaf children performed better than retarded children and the hearing children performed better than the deaf children. This study indicates that these deaf children were inferior in early life and although they showed progressive maturation, did not attain normal ability in locomotor coordination.

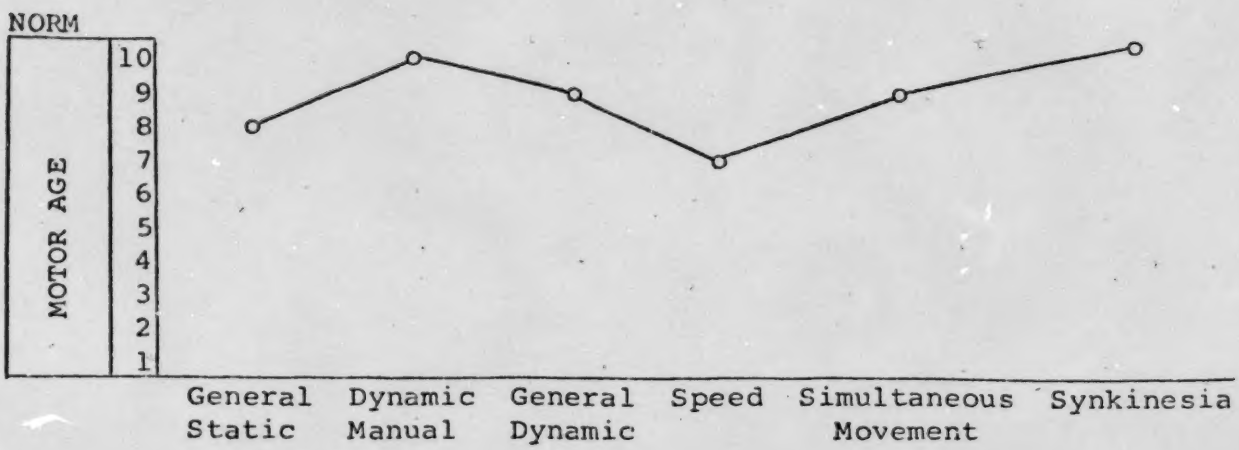
In a study of learning disabilities among deaf populations (Auxter 1973), perceptual-motor characteristics were compared to CA and IQ. The following areas of perceptual-motor skills were tested: sensory avenues of kinesthesis and vision, tasks of eye-hand coordination, gross body coordination, motor speed and balance. Two groups of 15 subjects each were used. The first group was comprised of 15 subjects who were learning academic tasks at expected levels commensurate with their IQ. This group had a CA range of 14.6 to 16.7 and a mean IQ of 105. The second group was educationally retarded in excess of 3 years. This group had a CA range of 15.0 to 17.1 and a mean IQ of 109.

No significant differences between groups appeared on sensory avenues of visual discrimination, eye-hand coordination and kinesthesis. The results of the tests which measured factors of a

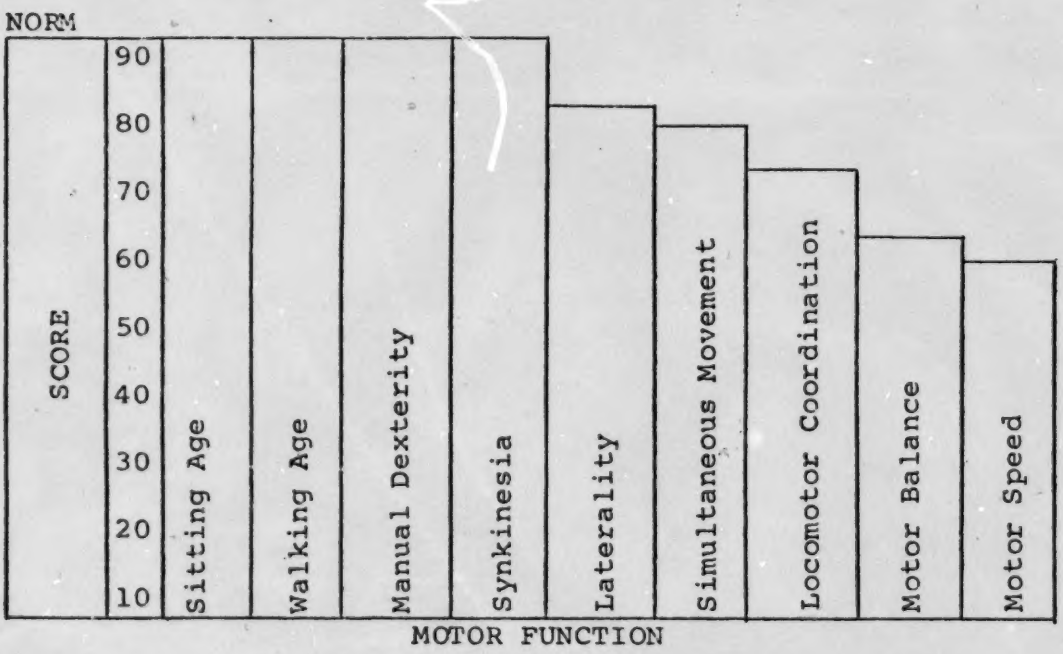
physical and motor nature, however, were significant. The results of these tests showed that significant differences existed between the groups on speed and limb movements, dynamic flexibility and the two-footed standing broadjump. Auxter concluded as follows:

> There is some evidence that the integrity of the motor behavior is closely associated with the integrity of the central nervous system; as in an organismic view of development in which there is reciprocity of function. It may be that the disability of motor planning and motor speed may have a disabling effect on the total development of deaf children. Therefore, the inability to perform tasks of motor speed may be indicative of sensory processing and motor planning, not only in the motor sphere, but also in intellectual tasks relating to academic success.

In a pilot study by Mykelbust (1960) using the Oseretsky Test of motor performance, it was found that the hearing impaired subjects were approximately 1½ years below the norm provided by Oseretsky for hearing children. The Oseretsky Test differs from most other motor tests in that it is designed to measure areas in much the way standardized tests measure intelligence (Oseretsky 1931). This type of test is especially useful in measuring motor performance in deaf children in that it appears to have a neurological frame of reference. Thus, Mykelbust's findings would seem to have great import. More revealing were the results on each of the 6 sub-areas tested for in the Oseretsky Test:



Mykelbust (1960), in a similar study, got similar results.



Kendall (1957) states that deaf children tend to sit and walk later than hearing children; however, Mykelbust (1954) found no significant difference. Because of the apparent interrelationship between mental age and ages for sitting and walking, it is obvious that intelligence must be controlled when making such comparisons.

Frisina (1955) found that mentally retarded, deaf children were significantly inferior to normal deaf children in ages of sitting and walking.

Carlson's (1972) assessment of motor ability of 48 deaf subjects found a significant relationship between motor performance and age below the age of 7. His subjects under the age of 7 scored considerably below the norms on the Brace Motor Ability Test.

In a comprehensive study comparing motor behavior in deaf and hearing boys (Boyd 1967), a significant difference between groups was found in but one motor area: static sense of equilibrium. Boyd pointed out that there were some deaf children who performed as well as hearing children, so that a generalization that every deaf child is significantly inferior in static equilibrium would be a misrepresentation of the data.

Also important in Boyd's study is the fact that he found no significant difference between deaf and hearing boys' performance in the following motor areas: locomotor coordination, psychomotor integration and speed. Boyd matched the hearing control group to the deaf experimental group with regard to age, sex and IQ. There were 90 boys in each group and IQ ranged between 94 and 106. In the deaf group, no subjects were accepted whose hearing loss was less than 65 dB for the speech range in the better ear. The mean hearing levels ranged from 80 to 90 dB. No subject in either group

was accepted who appeared to have any motor problem.

The significance of Boyd's study may be that, with the exception of static equilibrium, deaf and hearing children do not differ significantly on motor performance, making studies and resultant data with hearing children more generalizable to deaf children.

SUMMARY

This rather comprehensive look at motor behavior has surfaced a number of significant studies:

1) Gesell (1937) found that the rank order of the motor behavior of 5 children under investigation was the same at 5 years of age as it had been in early infancy.
2) Diem's (1970) efforts which have resulted in babies being able to swim without assistance at about 5 months of age. This development might eventually lead us to conclude that with proper intervention, motor skill acquisition of certain types can occur at an age much earlier than we now believe.
3) Dennis' (1963) finding that children aged 1-4 who were not provided with specific kinds of learning opportunities were retarded in normal locomotor development.

4) Gesell's (1941) work with feral children which clearly and convincingly shows that children tend to take on the characteristics of those with whom they most closely associate.

5) Bayley and Jones' (1937) and Scott's (1955) finding that children from a lower socioeconomic background developed motorically at a more rapid rate.

6) Geber and Dean's (1956), Monckeberg's (1968) and Cravioto's (1968) finding that undernourished infants and young children are retarded in both early mental and motor behavior; and Monckeberg's (1968) follow-up finding that motor development was still retarded even though the children had nutritionally recovered.

7) Singer and Brunk's (1967) finding that the highest relationship between motor performance and IQ in children ages 8-9 was with the youngest children.

8) Mykelbust (1960) and Boyd's (1967) disagreement concerning the motor performance of deaf children in comparison to hearing children. Mykelbust found the deaf subjects of his study to be inferior on static balance, speed and locomotor coordination; while Boyd found a difference only on static balance performance.

CONCLUSION

Based on the findings of this investigation of the literature, there is a need to study the environment of infants and children below the age of 6. In analyzing the environment, attention must be paid to: family socioeconomics, parent attitude toward all aspects of child development, the stimulation provided within the child's home, the motor abilities of the parents and siblings and the attitude toward nutrition and the type of diet provided the child.

A similar pilot study is also being planned in regard to cognitive development and the environment. From these two pilot studies might very well come evidence which will provide insights into the influence of the environment on motor and cognitive development of young children; and the interrelationship of motor and cognitive variables with very young children.

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